LOAD TESTS

LOAD TESTS
APPENDIX B

CONTENTS

LOAD TESTS

SYMBOLS USED IN THIS SECTION

DISCLAIMER

The information in this manual is provided as a guide to assist you with your design and in writing your own specifications.

Installation conditions, including soil and structure conditions, vary widely from location to location and from point to point on a site.

Independent engineering analysis and consulting state and local building codes and authorities should be conducted prior to any installation to ascertain and verify compliance to relevant rules, regulations and requirements.

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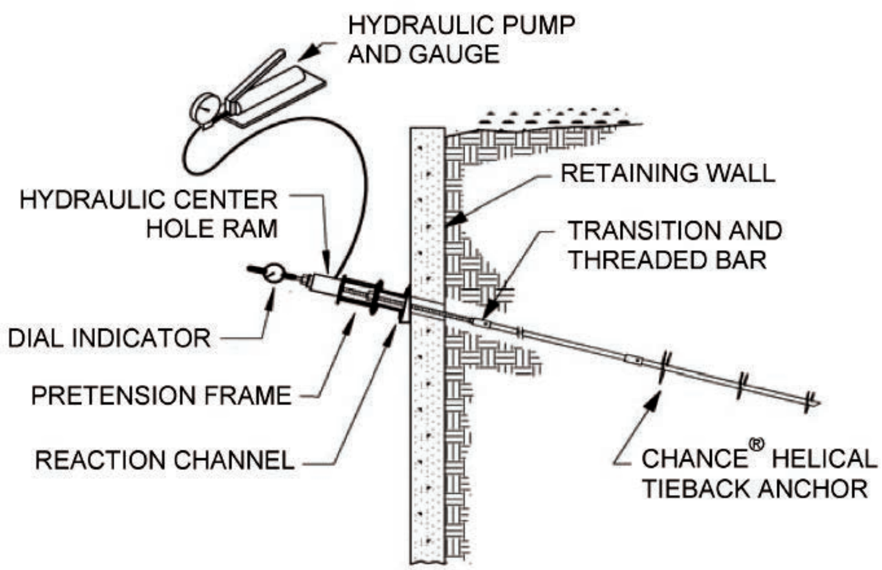
Hubbell Power Systems, Inc., does NOT warrant the work of its dealers/installing contractors in the installation of CHANCE® Civil Construction foundation support products.

STATIC LOAD TESTS (TIEBACKS)



It is recommended that the Field Load Tieback Test be conducted under the supervision of a Registered Professional Engineer. The engineer will specify the test and measurement procedure, load increments, time intervals and acceptable ultimate deflection consistent with specific project and load conditions. If the required ultimate load and test ultimate load results are close, the engineer may choose to adjust the tieback spacing, the length of installation to achieve greater installation torques, and/or the helical plate configuration on each tieback to achieve the desired Factor of Safety (FS).

Hardware Configuration for Performing a Load Test on a Retaining Wall or to Pretension a Wall with Soil Overburden.
Figure B-1

TEST PROCEDURE

WARNING! DO NOT ALLOW ANYONE TO STAND BEHIND OR IN LINE WITH THE THREADED BAR AND JACK DURING THIS TEST. SERIOUS INJURY MAY OCCUR IF A COMPONENT FAILS DURING TESTING.

1. Determine the required length of the helical tieback anchor to locate the helix plates into the target soil stratum as determined from the project boring logs. Use this data to select the tieback design and ultimate tension capacity and the estimated installation torque. Install the helical tieback anchor to the determined length and torque requirements.
2. If the soil overburden has not been excavated from behind the wall, connect the thread bar adapter/transition to the helical tieback by reaching through the hole in the wall. Install the continuously threaded bar, reaction channel, hydraulic ram (loading device), pretension frame (if required), dial indicator (or other measuring device such as Total Station Unit), hydraulic pump and gauge (see Figure B-1). The magnitude of the test pressure is determined as follows:

$$P_T \text{ (test pressure) psi} = \frac{\text{DL (design load) lbs x FS (Factor of Safety = 1.25 to 2.5)}}{\text{A (effective cylinder area) in}^2}$$

NOTE: The effective cylinder areas (A) are available from the manufacturers of center hole rams (i.e., Enerpac, Power Team, Simplex, etc).

The load application system, i.e., center hole ram and pump, shall be calibrated by an independent testing agency prior to the load testing of any tiebacks. For additional details, refer to the Model Specification - Helical Tieback Anchors for Earth Retention at http://www.abchance.com/resources/specifications.

An Alignment Load (AL), usually 5% to 10% of the Design (Working) Load (DL), should be applied to the helical tieback anchor prior to the start of field load tests. The initial alignment load helps to remove any looseness in the tieback shaft couplings and thread bar transition system.

3. Pre-Production Tests (Optional):

   Load tests shall be performed to verify the suitability and capacity of the proposed helical tieback anchor, and the proposed installation procedures prior to the installation of production tiebacks. The owner shall determine the number of pre-production tests, their location and acceptable load, and movement criteria. Such tests shall be based, as a minimum, on the principles of the performance test as described below. If pre-production tiebacks are to be tested to their ultimate capacity, then an additional purpose of the pre-production tests is to empirically verify the ultimate capacity to average installing torque relationship of the helical tiebacks for the project site. Testing above the performance test maximum applied load of 125% x DL should follow the loading procedures and increments as given in the Static Axial Load Tests (Compression/Tension) section to follow.

Anchor Tension Load Test in Minneapolis, MN
Figure B-2

LOAD TESTS

4. Performance Tests:

   The number of tiebacks that require performance testing shall be defined in the project specifications. The minimum number of tiebacks for performance testing shall be two (2). Helical tieback anchors shall be performance tested by incrementally loading and unloading the tieback in accordance with the Performance Test Schedule (see Table B-1). The applied load shall be increased from one increment to the next immediately after recording the anchor movement. The load shall be held long enough to obtain and record the movement reading at all load increments other than the maximum test load. The maximum test load (1.25 x DL) shall be held for a minimum of 10 minutes. Anchor movements shall be recorded at 0.5, 1, 2, 3, 4, 5, 6, and 10 minutes. Refer to Acceptance Criteria on page B-12 for additional hold periods, if required, and acceptable movement criteria.

5. Proof Testing:

   All anchors which are not performance tested shall be proof tested. The proof test shall be performed by incrementally loading the helical anchor in accordance with the Proof Test Schedule (see Table B-2). The load shall be raised from one increment to another after an observation period. At load increments other than the maximum test load, the load shall be held for a period not to exceed two (2) minutes. The two minute observation period shall begin when the pump begins to load the anchor to the next load increment. Movement readings shall be taken at the end of the two minute observation period.

   The dealer/installing contractor or engineer shall plot the helical anchor displacement vs. load for each load increment in the proof test. The 1.25DL test load shall be maintained for five (5) minutes. This five minute observation period shall commence as soon as 1.25DL is applied to the anchor. Displacement readings shall be recorded at 0.5, 1, 2, 3, 4, and 5 minutes. Refer to Acceptance Criteria on page B-12 for additional hold periods, if required, and acceptable displacement criteria.

Performance Test Schedule, Table B-1

PERFORMANCE TEST SCHEDULE				
CYCLICAL LOAD INCREMENTS (%DL/100)				
AL	AL	AL	AL	AL
0.25DL*	0.25DL	0.25DL	0.25DL	0.25DL
	0.25DL	0.50DL	0.50DL	0.50DL
		0.75DL*	0.75DL	0.75DL
			1.00DL*	1.00DL
				1.25DL*
				Reduce to lock-off load#

AL = Alignment Load, usually 10 to 15% of DL.
DL = Design (Working) Load
* The dealer/installing contractor shall plot the helical anchor movement for each load increment marked with an asterisk (*) in the performance schedule and plot the residual displacement at each alignment load versus the highest previously applied load.
# Helical tieback anchors which are performance tested may be completely unloaded prior to the lock-off load procedure. Final adjusting to the lock-off load does not require further movement readings.
See the Performance Testing Procedures in the Model Specification - Helical Tieback Anchors for Earth Retention at http://www.abchance.com/resources/specifications for further information regarding load test equipment, load test set-up, dial gauges for monitoring anchor displacement, etc.

Proof Test Schedule, Table B-2

PROOF TEST SCHEDULE	
LOAD TEST SCHEDULE (%DL/100)	OBSERVATION PERIOD (MIN.)
AL	AL
0.25DL	2.0
0.50DL	2.0
0.75DL	2.0
1.00DL	2.0
1.25DL	5.0
Reduce to lock-off load#	

AL = Alignment Load, usually 10 to 15% of DL.
DL = Design (Working) Load
# Helical tieback anchors which are proof tested may be completely unloaded prior to the lock-off load procedure. Final adjusting to the lock-off load does not require further displacement readings.
See the Proof Testing Procedures in the Model Specification - Helical Tieback Anchors for Earth Retention at http://www.abchance.com/resources/specifications for further information regarding load test equipment, load test set-up, dial gauges for monitoring anchor displacement, etc.

STATIC AXIAL LOAD TESTS (COMPRESSION/TENSION)

PRE-PRODUCTION LOAD TESTS

Load tests shall be performed to verify the suitability and capacity of the proposed helical anchor/pile, and the proposed installation procedures prior to installation of production helical anchors/piles. These load tests shall be performed prior to the installation of the production helical anchors/piles. The Owner shall determine the number of pre-production load tests, their location, acceptable load and displacement criteria, and the type(s) of load direction (i.e., tension, compression, or both). An additional purpose of pre-production tests is to empirically verify the ultimate capacity to the average installing torque relationship of the helical pile/anchor for the project site with the torque measurement equipment used for the project. Pre-production helical pile/anchor installation methods, procedures, equipment, and overall length shall be identical to the production helical anchors/piles to the extent practical except where approved otherwise by the Owner.

It is recommended that any field load test for compression or tension be conducted under the supervision of a Registered Professional Engineer. The engineer will specify the test and measurement procedure, load increments, time intervals, and acceptable ultimate displacement consistent with specific project and load conditions. Test procedures shall conform to ASTM D-1143-07, Standard Test Method for Pile under Static Axial Compressive Load and/or ASTM D3689-07, Standard Test Method for Pile under Static Axial Tension Load unless otherwise specified by the engineer. These ASTM specifications do not specify a particular method to be used, but rather provide several slow-testing and quick-testing optional methods.

Citing the Canadian Foundation Engineering Manual, 2007:

"The slow-testing methods . . . (outlined by the ASTM D1143-07. . . are very time-consuming. When the objective of the test is to determine the bearing capacity of the pile, these methods can actually make the data difficult to evaluate and disguise the pile true load movement behavior, thereby counteracting the objective of the test. The benefit of the (slow) test methods lies in the additional soil-pile behavior information, occasionally obtained, which the interpreting engineer can use, when required, in an overall evaluation of the piles.

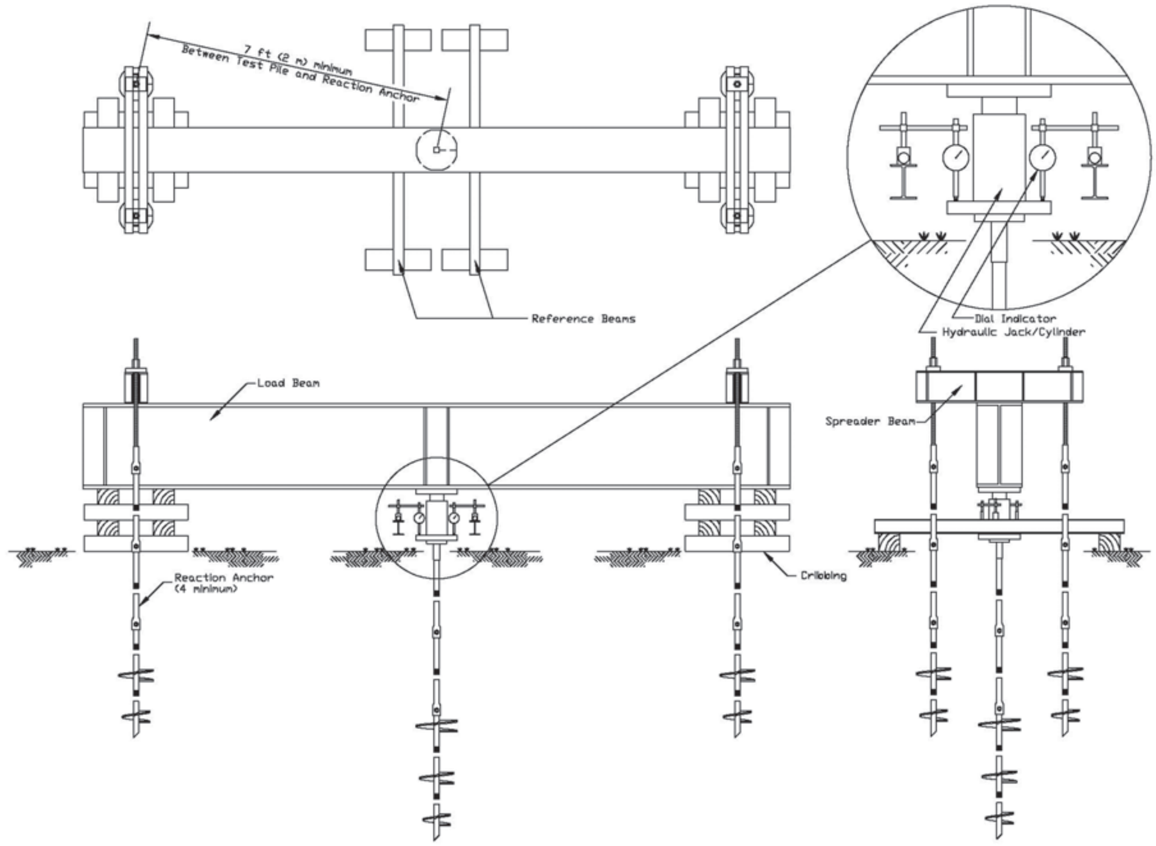
". . . For routine testing and proof testing purposes, the quick methods . . . are sufficient. Where the objective is to determine the bearing capacity of the pile . . . the quick test is technically preferable to the slow methods."

Therefore, the following test procedure is based on the "Quick Load Test Method for Individual Piles". This test procedure shall be considered to meet the minimum requirements for load testing. It is not intended to preclude local building codes, which may require the use of other testing methods as described in the ASTM specifications..

LOAD TESTS

PRE-PRODUCTION LOAD TESTS

1. Determine the depth to the target stratum of soil from the geotechnical site investigation report that includes boring logs. Use these data to select an pile/anchor design capacity, ultimate capacity and estimate the installation torque at the target stratum and depth.
2. Set the spacing and install the four reaction anchors at the test site (see Figure B-3). The recommended spacing between the test pile and the reaction anchors is at least 5D, where D = diameter of the largest helical plate. For tension only tests, the reaction anchors are not required.
3. Install the test helical pile at the centroid of the reaction anchors to the target depth and torque resistance. For tension tests, install the test anchor at the desired location to the target depth and torque resistance.
4. Mount the two anchor beams on the four reaction anchors/piles and the reaction beam between the anchor beams (see Figure B-3). For tension tests, center the reaction beam over the anchor and support each end of the beam on cribbing or dunnage. The helical reaction piles are not required if the surface soils have sufficient bearing strength to support the cribbing/dunnage under the applied loading without excessive deflections.
5. Install a load cell, hydraulic load jack, actuator and pressure gauge. The center hole load jack will be mounted below the reaction beam for a bearing (compression) test (see Figure B-3) and above the reaction beam for an anchor (tension) test. A solid core hydraulic jack can be used for compression tests.
6. Set the displacement measuring devices. Deflection measuring devices can include analog dial or electronic



Basic Compression Field Test Set-up
Figure B-3

Indoor Compression Test
Figure B-4

digital gauges (must be accurate to .001") mounted on an independent reference beam, a transit level surveying system, or other types of devices as may be specified by the engineer.

7. Apply and record a small alignment or seating load, usually 5% to 10% of the design load. Unless otherwise defined, the ultimate test load shall be assumed equal to 200% of the design load. Hold the seating load constant for 10 minutes or until no further displacement is measured.

8. Set the displacement measuring device(s) to zero.

9. Axial compression or tension load tests shall be conducted by loading the helical anchor/pile in step-wise fashion as shown in Table B-3 to the extent practical. Pile/anchor head displacement shall be recorded at the beginning of each step and after the end of the hold time. The beginning of the hold time shall be defined as the moment when the load equipment achieves the required load step. There is a generalized form for

LOAD TESTS

recording the applied load, hold periods, and pile/anchor head deflections provided at the end of this Section.

10. Test loads shall be applied until continuous jacking is required to maintain the load step or until the test load increment equals 200% of the design load (i.e., 2.0 x DL), whichever occurs first. The observation period for this last load increment shall be 10 minutes or as otherwise specified. Displacement readings shall be recorded at 1, 2, 3, 4, 5 and 10 minutes (load increment maxima only).
11. The applied test load shall be removed in four approximately equal decrements per the schedule in Table B-3. The hold time for these load decrements shall be 1 minute, except for the last decrement, which shall be held for 5 minutes. Refer to Acceptance Criteria on page B-13 for acceptable movement criteria.

NOTE: Refer to Helical Pile Load Tests in the Model Specification - Helical Piles for Structural Support at http://www.abchance.com/resources/specifications for further information regarding load test equipment, load test setup, dial gauges for monitoring anchor displacement, etc..

PRODUCTION LOAD TEST PROCEDURES (OPTIONAL - AS SPECIFIED)

1. Follow the test setup procedures listed under Pre-Production Load Test Procedures (Items 1 through 7), **except** the maximum test load to be applied to the pile/anchor is the Design Load (DL). (This may be the only type of load test conducted depending on the conditions.)
2. The Contractor shall perform axial load tests on the number and location of helical piles as specified by the Owner. At the Contractor's suggestion, but with the Owner's permission, tension tests may be performed in lieu of compression tests up to 1.00 DL for helical piles with sufficient structural tension capacity. The requirements of Table B-4 may be regarded as a minimum, however, it is not recommended to test production helical piles to values of up to 2.0 DL unless the helical pile's failure load is significantly higher than 2.0 DL. The maximum production helical pile test load shall be determined by the Owner. For example, ASTM D1143 stipulates testing to 2.0 DL.

Pre-Production Test Schedule, Table B-3

PRE-PRODUCTION TEST SCHEDULE			
CYCLICAL LOAD INCREMENTS (%DL/100)			
Load Increment	Hold Period (Min.)	Load Increment	Hold Period (Min.)
AL	1.0	AL	1.0
0.20DL	4.0	0.50DL	4.0
0.40DL	4.0	1.00DL	4.0
0.60DL	4.0	1.20DL	4.0
0.80DL	4.0	1.40DL	4.0
1.00DL	4.0	1.60DL	4.0
0.75DL	4.0	1.80DL	4.0
0.50DL	4.0	2.00DL	10.0
0.25DL	4.0	1.50DL	4.0
		1.00DL	4.0
		0.50DL	4.0
		AL	5.0
AL = Alignment Load, usually 10% of DL; DL = Design (Working) Load			

3. Axial compression or tension load tests shall be conducted by loading the helical pile/anchor in the load sequence as shown in Table B-4. Anchor/pile head displacement shall be recorded at the beginning of each step and after the end of the hold time. The beginning of the hold time shall be defined as the moment when the load equipment achieves the required load step. The observation period for this last load increment shall be 5 minutes or as otherwise specified. Displacement readings shall be recorded at 0.5, 1, 2, 3, 4, and 5 minutes (load increment maxima only).
4. The applied test load shall be removed in four approximately equal decrements per the schedule in Table B-4. The hold time for these load decrements shall be 1 minute, except for the last decrement, which shall be held for 5 minutes. Refer to Acceptance Criteria on page B-13 for acceptable displacement criteria.

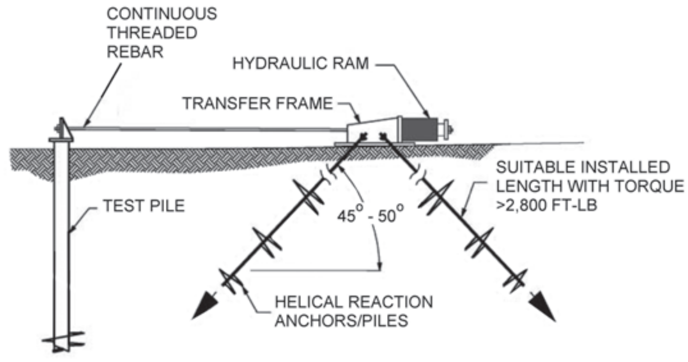
STATIC LOAD TESTS (LATERAL)

Helical pile/anchor offer maximum benefits structurally when loaded axially (concentrically) either in tension or compression. In certain design situations, the anchors/piles may be subjected to lateral loads and it is important to establish their lateral load capacity. Such applications may include support for communication equipment platforms, foundations for light poles, and sign standards or use as foundation systems for modular homes. It is recommended that the Field Lateral Load Test on pile/anchor be conducted under the supervision of a Registered Professional Engineer. The engineer will specify the test and measurement procedure, load increments, time intervals, and acceptable ultimate deflection consistent with specific project and load conditions. If the desired ultimate lateral load capacity and test lateral load capacity results are close, the engineer may choose to increase the diameter of the anchor/pile shaft and/or use a concrete collar on the anchor/pile head in order to achieve the desired Factor of Safety. Lateral load tests shall be conducted in accordance with ASTM D-3966-07, Standard Test Method for Piles under Lateral Load.

LOAD TESTS

Production Test Schedule (Optional - as Specified), Table B-4

PRODUCTION TEST SCHEDULE	
LOAD INCREMENT	HOLD PERIOD (MIN.)
AL	0
0.20 DL	4.0
0.40 DL	4.0
0.60 DL	4.0
0.80 DL	4.0
1.00 DL	5.0
0.60 DL	1.0
0.40 DL	1.0
0.20 DL	1.0
AL	5.0
AL = Alignment Load, usually 10 of DL. DL = Design (Working) Load	



Lateral Load Test Equipment Configuration
Figure B-5

Lateral Load Test Apparatus
Figure B-6

TEST PROCEDURE

1 . In order to conduct a lateral load test on an installed pile/anchor, it is necessary to install a reaction anchor system. The reaction anchor system consists of helical pile/anchor installed at a battered angle, and using a test apparatus setup such as shown in Figure B-5. Once the reaction anchor system is installed, the test pile/anchor is installed to the specified estimated depth and design torque.

2. Threaded steel bar or cable shall be used to connect the test pile to the reaction anchor frame. A hydraulic ram and pressure gauge is installed to apply the test load(s) and to measure the applied force.

3. Set the displacement measuring devices. Displacement measuring devices can include analog dial or electronic digital gauges (must be accurate to 0.001”) mounted on a reference beam, a transit surveying system, or other type of device as specified by the engineer.

4. For the Load Capacity Tests, follow steps 7 through 11 in the Static Axial Load Tests on page B-6 & B-7.

5. A failure criterion is often established by the project engineer and will reflect project specific conditions. The load versus lateral deflection is plotted. Interpretation of these results to determine the ultimate and working lateral load capacities often requires engineering judgment. Refer to Acceptance Criteria on page B-14 for acceptable displacement criteria.

CAPACITY VERIFICATION FOR ATLAS® RESISTANCE PIERS

On occasion, a building owner or engineer may want confirmation that existing ATLAS RESISTANCE® Pier underpinning is supporting the load as initially designed. Many times this request comes as a result of a client seeing tension cracks in the drywall or masonry. Many such requests are generated as a result of the owner failing to improve a poor drainage situation, from a failure to maintain the soil moisture around the perimeter of the structure or from leaks in the plumbing system. It is possible that the stratum upon which the pier is founded is receding. Changes can also occur that increase subsurface water near the structure such as a drainage system becoming clogged or an inoperative sump pump. In partial underpinning situations, additional loads may be imposed from adjacent areas experiencing further settlement resulting in a much greater load from the time of the previous installation. In these conditions, additional piers will be required along with adjustment of affected earlier installed piers.

The following gives the dealer/installing contractor and engineer guidance for answering these concerns and the engineer assistance with specifications for pier bearing verification.

TEST AND ADJUSTMENT PROCEDURE

1. Excavate and expose the top half of the pier bracket at each location to be tested and adjusted.
2. Check the pier pins to see if they are tight by tapping the heads of the pier pins with a hammer and then attempting to remove the pins using pliers.
   a. If the pier pins are loose:
      - The pier may be bearing on a stratum that is receding or that has deteriorated. Load test the pier.
      - The pier pipe or pier bracket component may have failed. If inspection of the components reveals a failure, replace the failed component and return it to Hubbell Power Systems, Inc. for evaluation. Load test the pier.
      - The footing may have heaved from expansion of the underlying soil if the floor slopes toward the interior. If evaluation of the structural elements, elevation measurements, drainage, and soil moisture content reveals heaving, then correcting the drainage or plumbing may allow the pier to return to the desired elevation. Schedule another inspection after the remedial work is complete and the soil has stabilized.

   b. If the pier pins are tight but the floor slopes toward the perimeter:
      - The interior floor may be heaving. If an evaluation of the structural elements and elevations reveal interior heaving, a plumbing test, an evaluation of the surface drainage, and subsurface soil conditions should be performed and the deficiencies must be corrected before any attempt to adjust the perimeter is performed.
      - The bearing stratum may be receding or compressing under the pier load as the structure continues to settle. Load test the pier.
3. Load testing procedure for ATLAS RESISTANCE® Piers:
   a. Install a lift head onto the pier bracket and place a 25 ton hydraulic ram with hose, gauge, and hand pump on the top pier platform.
   b. Slowly advance the ram while monitoring the top pier platform for creep.
   c. If little or no movement is observed, then the end of the pier is probably still founded upon competent material. Continue to increase the force on the ram until the structure begins to lift. (If the pier advances into the soil more than the stroke of the ram, skip to step f below.)
   d. Record the load test force that was required to begin to lift the structure. The formula for this force is: Gauge Pressure x 5.15 = Verification or Test Force (verify effective area of ram).
   e. Compare this force to the force indicated on the original pier log. (Variation of ±15% is acceptable.) (Skip to step i below.)
   f. Remove lift head assembly and top pier platform and install the pier driving equipment, drive stand, hydraulic drive cylinder, gauge, and gasoline or electric pump. Drive the pier pipe as if this was a new installation until suitable bearing is obtained. Record the driving force. The formula for this force is: Gauge Pressure x 8.29 = Driving Force (verify effective area of drive cylinder).
   g. Cut the added pier pipe to proper length and record the added length required at this pier.
   h. Install the top pier platform and lift head.
   i. Repeat steps a through e for **each pier that requires load bearing verification**.
4. Procedure for Adjusting Piers:
   a. Prepare a system of hydraulic rams and manifold(s) that are connected to all of the piers that need to be adjusted. Follow the normal elevation recovery procedure as described in the Typical Specification for the

ATLAS RESISTANCE® Pier system being tested. Typical Specifications are available on the Hubbell Power Systems, Inc. website, www.abchance.com.

b. Carefully apply pressure using the hand pump to restore the lost elevation. Valve off each ram as the foundation elevation reaches the target. Record the lifting force and the amount of lift at each placement. The formula is: Gauge Pressure x 5.15 = Lifting Force.

c. Once the structure has reached the target elevation, install pier shims and pier pins as described in the Typical Specification for the ATLAS RESISTANCE® Pier system being tested. The Typical Specifications are available on the Hubbell Power Systems, Inc. website, www.abchance.com.

d. Carefully reduce the hydraulic pressure at each ram, remove the rams and lift heads

e. Replace and compact the excavated soil and leave the area clean and neat.

5. Report the results:

a. A Pier Installation Report shall be prepared that includes:
- A pier layout of the area of work with each pier location indicated,
- The verification or test force,
- The amount of downward movement required before reaching this force,
- The lifting force, and
- The amount of lift that was required to restore the foundation to the target elevation.

b. Report to the engineer or owner any surface or subsurface drainage conditions observed and any suspected plumbing problems (such as water seeping into all or only several excavations). It is important that the Owner understand that any plumbing leaks or drainage deficiencies that are observed at the time of the adjustment be corrected immediately, otherwise stability issues may continue.

ACCEPTANCE CRITERIA

Static Load Tests (Tiebacks)

PRE-PRODUCTION AND PERFORMANCE TESTS

The net displacement shall not exceed 0.05" during the first log cycle of time, i.e., 1 min to 10 min. If the anchor movement between the one (1) minute and ten (10) minute readings exceeds 0.05", then the 1.25 DL test load shall be maintained for an additional 20 minutes. Displacements shall be recorded at 15, 20, 25, and 30 minutes. Net displacement is the difference between the movement recorded at the initial time increment and the final time increment of the log cycle of time. The initial time increment is 1 min and the final time increment is 10 min for the first log cycle of time for Pre-Production and Performance Tests.

The net displacement shall not exceed 0.10" during the final log cycle of time (examples, 3 min to 30 min, 6 min to 60 min, etc). If the acceptance criteria is not satisfied, then the anchor test shall be continued for an additional 30 minutes. Displacements shall be recorded at 45 and 60 minutes. If the acceptance criteria is not satisfied after this extended observation period, then the contractor shall exercise one of the options as provided in Section 6.5, Acceptance Criteria, in the Model Specification - Helical Tieback Anchors for Earth Retention found on www.abchance.com.

PROOF TESTS

The net movement shall not exceed 0.05" during the first log cycle of time, i.e., 0.5 min to 5 min. If the anchor movement between the one-half (1/2) minute and five (5) minute readings exceeds 0.05", then the 1.25 DL test load shall be maintained for an additional 5 minutes. Displacements shall be recorded at 6 and 10 minutes.

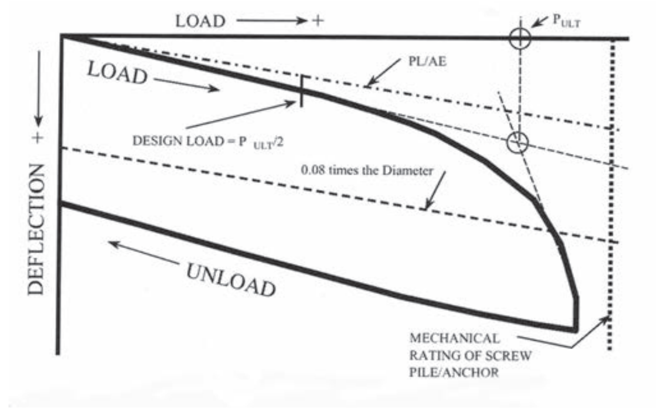
The net displacement shall not exceed 0.10" during the final log cycle of time (examples, 1 min to 10 min, 3 min to 30 min, etc). If the acceptance criteria is not satisfied, then the anchor test shall be continued for an additional 20 minutes. Displacements shall be recorded at 15, 20, 25, and 30 minutes. If the acceptance criteria is not satisfied after this extended observation period, then the contractor shall exercise one of the options as provided in Section 6.5, Acceptance Criteria, in the Model Specification - Helical Tieback Anchors for Earth Retention found on www.abchance.com.

Static Axial Load Tests (Compression/Tension)

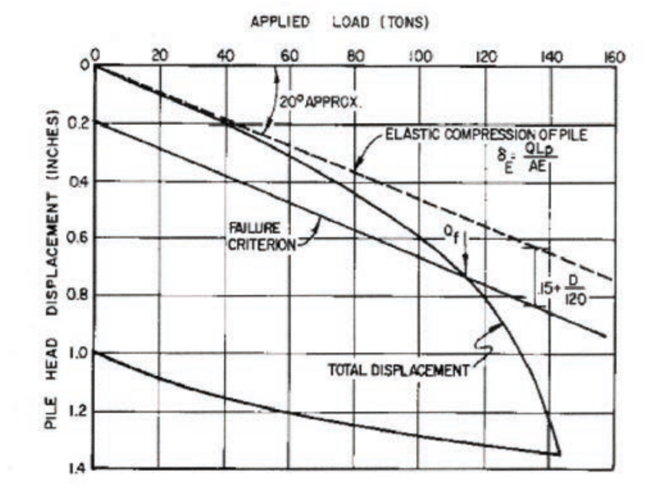
PRE-PRODUCTION LOAD TESTS

Acceptance of the load test results is generally governed by the building code for that jurisdiction and is subject to review by the structural designer. The structural designer determines the maximum displacement the structure can withstand without undue loss of function or distress. The acceptance criteria must be defined prior to conducting the load test.

The load displacement data may be plotted for a quick overview of the results. Figure B-7 shows a sample test plot. Various building codes have their own acceptance criteria, which is generally a limit on deflection at the factored load. A fast way to determine the ultimate geotechnical capacity is by use of a technique called the "intersection of tangents." This is accomplished by graphically constructing two tangent lines. One line is drawn tangent to the second "straight line" portion of the load curve, which is beyond the curved or non-linear portion of the load deflection curve. The other line is drawn tangent to the initial "straight line" portion of the load deflection curve. The point where the two tangents intersect identifies an estimate of the ultimate capacity.



Sample Compression Test Load-Deflection Curve
Figure B-7



Davisson Method for Determining Net Displacement
Figure B-8

An example of a Code-based acceptance criteria for the allowable capacity is the Chicago and New York City Code, which calls for the design load to be the lesser of:

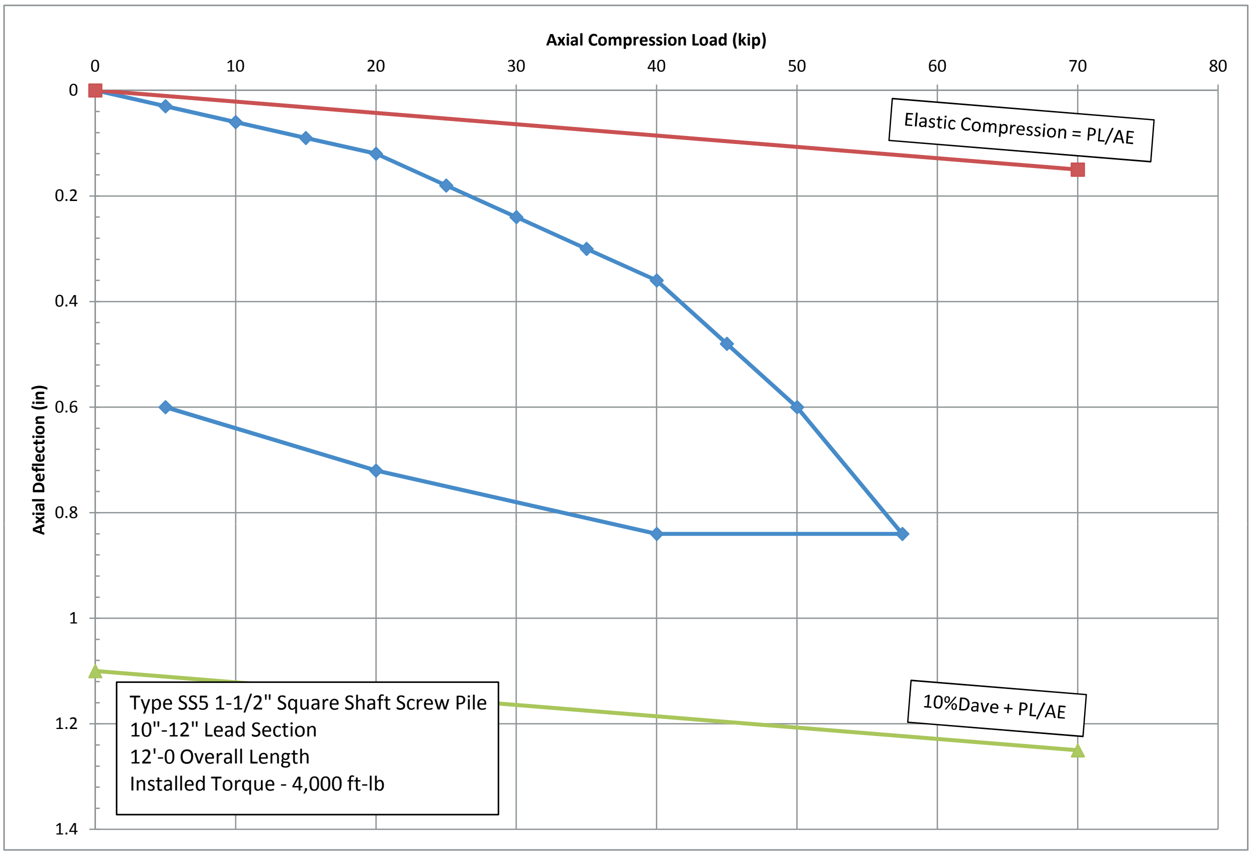
1. 50% of the applied load causing a net displacement (total displacement less rebound) of the pile of 0.01" per ton of applied load, or
2. 50% of the applied load causing a net displacement of the pile of 1/2". Net displacement is defined as the gross displacement at the test load less the elastic compression.

Other allowable capacity acceptance criteria include:

- Maximum total displacement under a specified load.
- Maximum net displacement after the test load.
- Maximum displacement under the design load, or various techniques such as that defined by the Davisson Method (1973) and shown in Figure B-8.

The recommended acceptance criteria for the allowable geotechnical capacity for helical piles/anchors is 1/2 of the applied test load causing a net displacement (gross displacement less the elastic compression/tension) not to exceed 0.10 times the average diameter of the helix plate(s). This is the acceptance criteria used in ICC-ES Acceptance Criteria AC358 for Helical Systems and Devices, per Section 4.4.1.2.

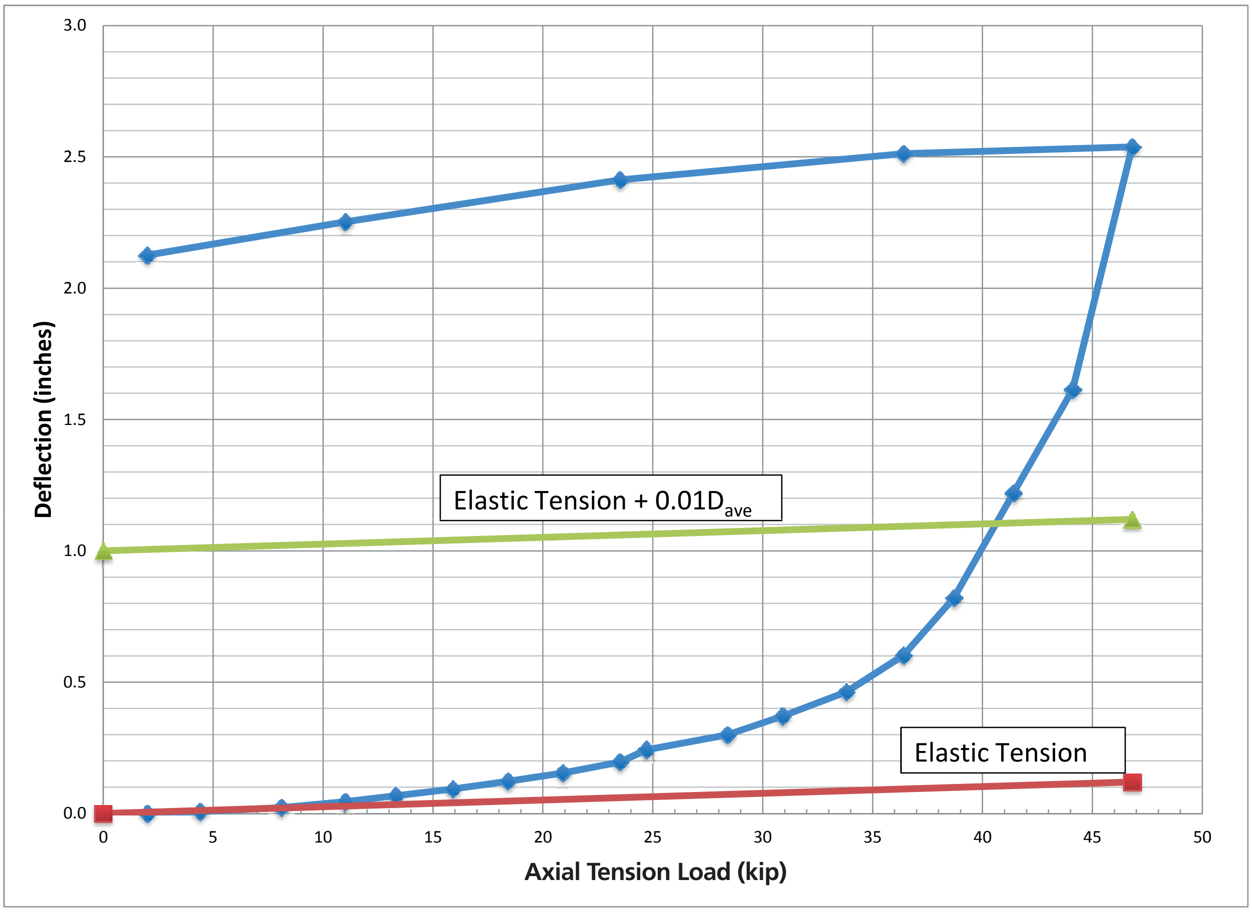
When relatively low foundation capacities are required, the allowable capacity for helical piles/anchors might be based on minimum depth and minimum torque criteria. This is similar to what the New York City code for driven piles up to 30 tons requires, which is to define capacity by the minimum "blows per foot of set." The subject of load tests and acceptance criteria are discussed by Crowther (1988) and may be referred to for a more complete treatment of the subject.



ASTM D1143 "Quick Test" Compression Plot
Figure B-9

Figure B-9 is a plot of results from a compression "quick test" per ASTM D1143-07 of a 12 ft long, 1-1/2" square shaft helical pile having 10" and 12" helix plates. It was installed in the residual fine grained soils of Roanoke, Virginia and tested immediately after installation. The load-displacement curve is completely below the elastic compression line, indicating no skin friction was acting on the shaft during the test. The load-displacement curve does not cross the PL/AE + $0.01D_{ave}$, which indicates the maximum test load is less than the ultimate geotechnical capacity of the helical pile.

Figure B-10 is a plot of results from a tension "quick test" per ASTM D3689-07 of a 16 foot long, 1-1/2" square shaft helical anchor having 8", 10" and 12" helix plates. It was installed in the residual fine grained soils of Centralia, MO and tested immediately after installation. The load-displacement curve is completely above the elastic tension line (red line), indicating no skin friction was acting on the shaft during the test. The load-displacement curve crosses the PL/AE + $0.01D_{ave}$ line at approximately 41 kip. The average installation torque over the last three readings was 3,450 ft-lb. The torque correlation method (K_t) of capacity prediction says the ultimate geotechnical capacity is 3,450 x 10 = 34,500 lb (34.5 kip), using a K_t of 10 ft^{-1} as outlined in Section 6. The tested ultimate geotechnical capacity based on 10% average helix diameter net displacement is 41 kip. Therefore, the K_t based on the load test is 41,000/3450 = 11.9 $\cong$ 12.



ASTM D3689 "Quick Test" Tension Plot
Figure B-10

PRODUCTION LOAD TESTS (OPTIONAL)

Some projects are large enough in size to justify the expense of several production tests. Production tests are useful to verify helical anchor/pile capacity at multiple locations across the project site, especially with varying soil conditions. The net displacement of helical anchor/piles at the allowable load (1/2 the geotechnical capacity) typically ranges between 0.25 inches (25 mm) and 0.5 inches (51 mm) total vertical movement as measured relative to the top of the helical anchor/pile prior to the start of testing. The Owner or structural engineer usually determines what the allowable displacement is, and it must be defined prior to conducting the Production Load Test. Limiting axial net deflections of 1" to 1-1/2" at the ultimate geotechnical capacity are typical.

STATIC LOAD TESTS (LATERAL)

Acceptance Criteria for Helical Systems and Devices AC358 states the allowable load capacity shall be equal to half the load required to cause 1 inch (25 mm) of lateral deflection as measured from the ground surface. The acceptance criteria must be defined prior to conducting the Lateral Load Test. The acceptance criteria must be realistic in its magnitude so as not to potentially damage the structure. Limiting lateral deflections of 1"+ at the ultimate load capacity have been used on some projects. It is suggested that large lateral loads be resisted through some other means (such as helical anchors, battered helical piles, or enlarged concrete pile caps/grade beams).

LOAD TESTS

CHANCE® HELICAL PILE/ANCHOR AXIAL TEST

Project:	Date:	Sheet of
Anchor/Pile Number:	Anchor/Pile: ☐ SS5 ☐ SS150 ☐ SS175 ☐ SS200 ☐ SS225 ☐ RS	
Helix Configuration:	Total Depth:	
Time: Start Finish	Recorded by:	

PRESS (psi)	LOAD (kip)	TIME (min)	DISPLACEMENT		
			GAUGE A (in)	GAUGE B (in)	GAUGE C (in)

References

1. AC358 Acceptance Criteria for Helical Systems and Devices, ICC-Evaluation Services, June 2013 Revision.
2. ASTM D1143-07, Static Load Test Method for Piles under Static Axial Compressive Load, American Society for Testing and Materials, Philadelphia, PA.
3. ASTM D3689-07, Standard Test Method for Pile under Static Axial Tension Load, American Society for Testing and Materials, Philadelphia, PA.
4. ASTM D-3966-07, Standard Test Method for Piles under Lateral Load, American Society for Testing and Materials, Philadelphia, PA.
5. Canadian Foundation Engineering Manual, Canadian Geotechnical Society, 1985.
6. Crowther, Carroll L., Load Testing of Deep Foundations, John Wiley and Sons, 1988.
7. Davisson, M.T., High Capacity Piles, Department of Civil Engineering, Illinois Institute of Technology, Chicago, IL, 1973.